SENIOR THESIS
Department of Geological Sciences
The Ohio State University

Submitted in partial requirement of Bachelor of Science
Degree, Geological Sciences

STUDY OF KARST AREA IN NORTH-WESTERN DELAWARE COUNTY, OHIO

By Carolyn Able
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ADVISING PROFESSOR: Dr. M. Hansen

ACKNOWLEDGMENTS

I would like to thank Mr. Rick Pavey, Geologist - Ohio Department of Natural Resources, for assistance in conducting my research. He provided me with support material and assisted me in proper use of the aerial photographs. I would also like to thank Mr. Scott Brockman, Geologist - Ohio Department of Natural Resources, for the assistance with the soil map interpretations. The residents of the mapping area were particularly helpful in providing information about the sink holes and caves. Mr. Rowland and Mr. Dewitt were very knowledgeable about this area, and provided unlimited access to the primary cave and sink hole locations. I would also like to thank my advisors, Dr. Michael Hansen and Dr. Gary McKenzie for all of the suggestions and assistance during my research project. Additionally, I thank my co-workers who allowed me to utilize my work space for my project.

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ABSTRACT

Field mapping, aerial photographs and soil maps were used in an attempt to determine if a study area in north-west Delaware County, Ohio, had karst features present. While conducting this study, an attempt was made to correlate features on the aerial photographs to karst features. A similar attempt was made to correlate a particular soil(s) with the presence of karst. Research was also conducted on this area to determine the geologic history in order to explain the different topography displayed in the study area from the surrounding areas to the north and south. The field mapping did identify the presence of karst through the detection of sink holes and caves in limestone in the study area. Some correlation could be made to the aerial photographs, but little correlation could be made with the soils. The aerial photographs provided an excellent initial source for detecting depressions. The presence of the depressions indicated the presence of a sink hole that in turn identified a karst environment. However, the larger sink holes and caves were found in wooded areas resulting in the aerial photographs being less helpful. A specific correlation could not be made between the soils and karst environment. The two most common soils in the study area are present where the karst features were discovered. Therefore, a correlation cannot be predicted because the law of averages could be the reason rather than an interdependence between a particular soil and karstification.

INTRODUCTION:

The first objective of this research was to determine and map the nature, extent and indicators of a suspected karst region located in Northwestern Delaware County. The second objective was to determine the reason(s) for the topography of this region. The area is designated by the following boundaries: U.S. Route 36 to the south, U.S. Route 37 to the north, the Scioto River to the west and South Section Line Road to the east (fig. 1). The karst investigation was conducted in conjunction with the Ohio Department of Natural Resources (ODNR). The outcome

of this study will aid in the Low Level Radioactive Waste Karst Terrain Mapping Project that ODNR has undertaken (R. Pavey, personal communication). The emphasis of the project was to determine significant factors or evidence that indicate the presence of karst in an area and to research the geologic history of the region in order to identify factor(s) that resulted in the present topography of the study area. The study began with research of published material for the region. A field mapping project was included in the research in order to make current observations of the area. After conducting a study of the area, I have concluded that a karst system does exist within the defined area and that past glacial events have led to the present-day topography.

PROCEDURES:

The study area is within the Ostrander 7 ½ - minute Quadrangle (fig. 1). Some of the sink holes that indicate a karst environment were already identified on this map. This map was based on aerial photographs taken from 1959 to 1960. The current mapping project utilizes aerial photographs taken in 1951, as a field tool. Current field mapping was required because it was suspected that the region had undergone changes in the number of sink holes and possible caves because of the solution and erosional nature of karst environments. The topographic map and the aerial photographs provided an indication of karst features and a starting point from which to begin the field mapping assignment.

After preliminary library study of the area, a site inspection of the region was done by car in order to become familiar with the area, the roads and the land/home owners. This also provided and opportunity to present information about the study to the residents of the area and to request land access (fig. 2). Five additional mapping trips were conducted on foot over the study area. The aerial photographs and the topographic map were used while field mapping; data was recorded onto the topographic field map. The sink holes and caves were marked on the topographic map as they were discovered (fig. 5).

In addition to the aerial photographs, the soil maps from Delaware County were used in an attempt to correlate the presence of a particular soil with the presence of a karst environment (fig. 3). Water well logs from Scioto and Radnor Townships were used to gather more information about the area, possibly leading to a correlation among karst environments and related factors (figs. 10 & 11). A cross-section for the study area was developed from the well log information (fig. 4). This research and field work resulted in observations of the study area.

OBSERVATIONS:

Field Mapping:

More sink holes were found during the field mapping exercise than those depicted on the topographic map or visible in the aerial photographs (fig. 5). The area where most of the larger sink holes and all of the caves were located was east of Warren Road in an area commonly referred to as the Rowland's Cave area and the Dewitt Spring area. Another area with an abundance of smaller sink holes was to the north and south of the western portion of Warrensburg Road. Sink holes and caves were not found in the eastern part of the study area. The sink holes and caves were on the upland area just east of the Scioto River.

The sink holes and caves varied in size. The sink holes ranged from approximately 1 meter in diameter to 6 meters in diameter. Some of the larger sink holes had openings in the bottom that ranged from a few centimeters to 1 meter in diameter. The openings were predominantly positioned on the westernmost part of the bottom of the sink hole. The depressions were narrow in the easterly direction and were wider in the westerly direction. The sink holes and caves both demonstrated this feature. They were deeper and wider in the westerly direction toward the Scioto River. Fossiliferous limestone rock debris were found in the bottom of most of the sink holes that had openings and in all of the caves.

Two caves were discovered while field mapping. They were at the base of sink holes. The cave identified as #5 in figure 5 is approximately 6 meters from east to west and about 3 meters from north to south. The cave entrance was large enough for a person to enter. The cave identified as #8 in the same diagram was smaller. It too is located in the base of a large sink hole, but its opening is only approximately 1 to 2 meters.

Two springs were identified close to the Scioto River. Sink holes and caves were not present in this area. These two springs were documented on the basis of interviews with local residents (R. Rowland, L. DeWitt; personal communication). One of the springs is to the north-west near the Old Stone Church and the other in to the south-west along Warren Road (Dewitt Spring). Mr. Dewitt, who owns a farm on Warren Road, indicated that a study was conducted on the hydrology of the cave system by a student from Wittenberg University. The study included a dye tracer (fig. 6) that was introduced to the cave system in the Rowland's area. The dye was detected at the Dewitt Spring.

Aerial Photographs:

The aerial photographs provided a starting point for the field mapping exercise; however, most of the sink holes and caves were found in moderately wooded areas (figs. 8 & 9). The field cover resulted in the depressions not being detectable in an aerial photograph. The aerial photographs were helpful in distinguishing wooded areas in cleared fields. These clusters of woods provide an indication that some reason such as a depression could be the explanation for the uncleared area.

Soil Maps:

Sink holes and caves were found primarily in the Morley Soil Series (fig. 3). Morley Soils are light-colored, moderately well-drained soils primarily found on uplands. They are formed in limy, silty clay loam or clay loam, glacial till of Wisconsinan Age. Underlying this soil series is a

firm, calcareous, brownish glacial till of silty clay loam and clay loam texture. The clayey subsoil restricts the movement of water. The Morley Soil that is present in the Rowland's Cave area is a series of gently sloping soils that occupy large irregular areas on undulating uplands. Where the Morley Series makes contact with the Blount Soil Series, pockets of poorly drained areas can be detected (Soil Survey Delaware County, Ohio, 1969).

The Blount Series is composed of light colored, poorly drained soils formed in clay loam of silty clay loam, glacial till of Wisconsinan Age. The soils are level to gently sloping and occupy broad areas of uplands in the western area of Delaware County. The substratum to this series is a calcareous base consisting of glacial till with 20% to 35% carbonate. This soil demonstrates slow permeability and is saturated with free water during seasonal rains (Soil Survey Delaware County, Ohio, 1969).

The Morley-Blount Association is present in the areas of the most predominant karst environment. This area is somewhat poorly drained with gently sloping to steeply sloping soils on an undulating glacial till plain (Soil Survey Delaware County, Ohio, 1969). This association is found in the area where the greatest abundance of sink holes and caves were identified.

INTERPRETATIONS:

Presence of a Karst Environment:

The topographic map and aerial photograph research provided a strong indication that a karst environment was present in the study area. However, until field mapping was concluded there was no way to determine the magnitude of the karstification. The presence of sink holes and caves in addition to the limestone terrain confirmed a karst environment. The fact that more sink holes and caves were found during field mapping assisted in proving the presence of karst. A karst region requires that land-forms be developed by solution. The study area has been subject to solution and erosion over time because of its limestone-carbonate composition in a humid,

temperate environment. Limestone admits water along joints, bedding planes and faults. It appears that the study area is affected by the presence of joints and bedding planes.

Abundant joints that follow the bedding plane and nearly vertical joints that cut across the bedding planes are present in this location (Westgate, 1926). The presence of joints along with changes in temperature and frost action, all contributes to the rapidity of the chemical solution process. Ground water flows through the joints in the Delaware and Columbus Limestones. The surface water flowing along the cracks has dissolved the limestone and widened the opening to fissures. This wider opening provides the water easier access to the limestone. This process is evident in the upper part of the Columbus Limestone. Along the Scioto River near the Rowland's Cave area, the enlarged cracks became sink holes at the surface and eventually caves. A succession of sink holes and caves can be traced along the east boundary of the Columbus Limestone north from the Delaware-Marysville Road for 3.2 kilometers, and along the east side of the Delaware limestone outlier north from Rathbone (Westgate, 1926).

The caves that are in the Rowland's Cave area are low and wide. These features indicate that the water most likely followed a bedding plane crack (Westgate, 1926). The first stages of solution are the most critical to the formation of the sink hole/cave because these stages greatly affect the pattern of the resulting karst system (Howard, 1967). The presence of large caves is associated with swallet features that localize the sinking streams and result in large cave systems. This feature also explains the presence of springs near the Scioto River. However, it is also apparent that percolation is acting on this environment because of the presence of small sink holes. These two systems are influenced by soil and vegetation along with the presence of jointing, bedding planes and faulting (Newsom, 1973). Most of the land in the study area has been cleared for farm land with the exception of the Rowland's Cave area. There is a wooded area on the north side of Warrensburg Road that is thought to have sink holes and caves; however, the landowner

would not allow mapping access to the wooded areas of his land (fig. 5, areas A and B). The reason that the openings of the sink holes and caves are most pronounced in the westerly direction can be associated with the fact that the water will always tend to flow along gradient or the path of maximum potential difference (de Ausssure, 1963).

Soil Correlation:

Sink holes and caves are present at the Morley and Blount Soil Association However, there is no direct correlation that can be made to the presence of the Morley and Blount soils and the presence of karst. More research needs to be conducted in this area before a decision can be made about this possible correlation. One area that may provide more productive results would be investigating the presence of calcareous material in the soil content. Both the Morley and the Blount soils have underlying units that were of a calcareous content. However, this study area does not cover a large enough territory to make that correlation either.

Geologic History of the Study Area:

Continental glacial ice once covered the study area. The Illinoian and Wisconsinan age ice sheets resulted in the formation of end moraines in Delaware County (fig. 7). The Broadway Moraine appears to account for the different topography of the study area compared to the flatter areas to the north and south. The Broadway Moraine enters the county near Ostrander and circles to the north. About 5 kilometers northwest of Delaware, it turns again to take on a more easterly course (Westgate, 1926). The surface of the moraine drops more abruptly on the south side and more gently on the north side. Areas of thick drift may be attributed to the alternating advance and retreat of the glacier across a narrow belt. The surface of the moraine is generally rolling (Westgate, 1926).

CONCLUSION:

The study of an area in North-west Delaware County was conducted to prove or disprove the presence of karst. All indications suggest that this is a karst environment. The presence of limestone along with sink holes and caves is the most convincing find. The correlation among factors such as soil content and depressions on aerial photographs are not as convincing. The soil correlation to a karst environment cannot be made based on this study alone. The most common soil type in the study area was the soil where the karst features were found. This could either support a correlation theory or simply follow the law of averages. The use of aerial photographs in determining karst features can be very useful. Some depressions are easily identified in cleared fields. These depressions are an indication of possible karst features. However, the most effective way of accurately identifying karst areas is by field mapping. All of the large sink holes and caves were found in wooded areas that cannot be determined by aerial photograph because of the cover of vegetation.

The topography of this area can be explained by the geologic history of the area. The movement of continental glaciers produced the Broadway Moraine. The moraine cuts through the study area resulting in a different topography on the moraine than that to the north and south of the study region. The Scioto River also cuts through the moraine increasing the difference in elevation from the river to east of the study area.

The confirmation of the presence of karst in this area will provide some guidance in the karst mapping for the remaining areas of Ohio. The combination of aerial photographs with field mapping should provide great insight into the composition of the terrain in question.

REFERENCES CITED

de Saussure, R., Jan./Feb. 1963, Cave Notes: A Review of Cave and Karst Research, Vol. 5, No. 1, "The General Formation and Development of Limestone Caves," 5 p.

Howard, Alan D.; Howard, Barbara Y.; July/Aug. 1967, Cave and Karst: Research in Speleology, Vol. 9, No. 4, "Solution of Limestone Under Laminar Flow Between Parallel Boundaries," 3 p.

Newsom, M.D., Mar. 1973, Cave Science, Vol. 50, "The Hydrology of Limestone Caves," 12 p.

U.S. Department of Agriculture, Jul. 1969, Soil Survey Delaware County Ohio, 76 p.

Westgate, L.G., 1926, Geology of Delaware County: Geological Survey of Ohio, Series 4, Bulletin 30, 147 p.

FIGURES CITED IN THE TEXT

Figure 1: Map of study area. This attachment shows the boundary of the study area and street names. It also depicts the traverse for the cross section and provides some locations for water wells located in the area.

Figure 2: Letter to residents in study area. This letter was provided to residents in order to explain the project.

Figure 3: Soil Map. The soil map shows the different soils that are present in the mapping area. The two most common soils are Morley and Blount. Other soils are included on the map, but they were not significant to the study. Some of these soils were combined into one designated color when the soil types were similar (Fox, Ockley and Westland).

Figure 4: Cross-section derived from well logs. The cross section traverse is depicted in Figure 1. Only a limited number of wells were in the study area; therefore, the cross-section is based on interpretation from 4 wells

Figure 5: Sink hole and cave map. This map depicts the caves and sink holes mapped in the study area. Sink holes that were identifiable by aerial photographs are distinguished on the map. The wooded area that was not mapped is identified with "no access." The DeWitt spring area and the Rowland's cave area are identified also.

Figure 6: Pictures of dye tracer. A: Stream at the DeWitt Spring area. B: Opening of the DeWitt Spring.

Figure 7: Map of moraines. The Broadway moraine is identified on this attachment.

Figure 8: Aerial photograph. This photograph shows the western area of the study region. (Note: figure 8 and 9 should be used together).

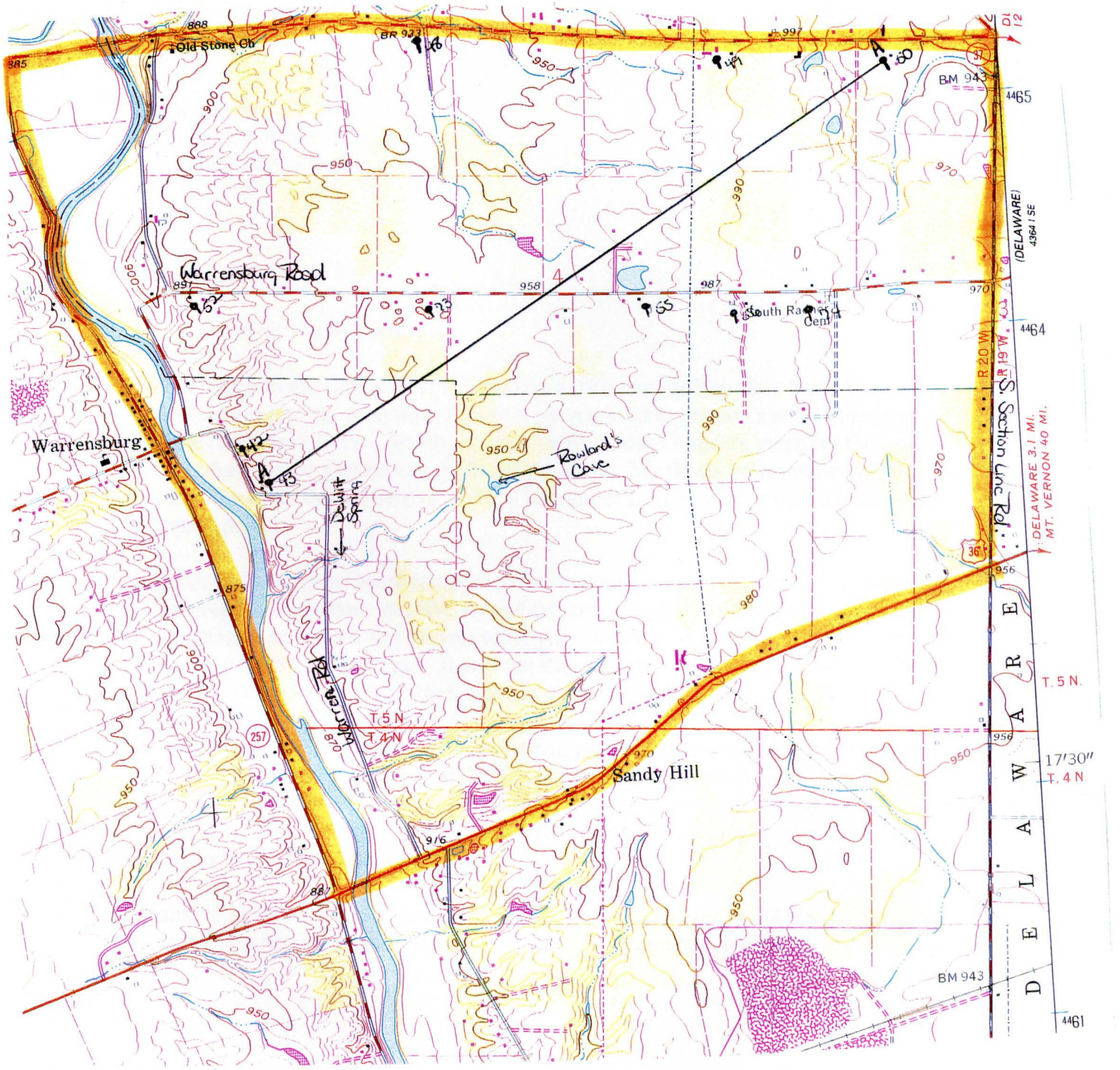
Figure 9: Aerial photograph. This photograph shows the eastern area of the study region.

Figure 10: Water well log. This log is an example of the water well logs used for the cross section.

Figure 11: Water well log. This is an example of the water well logs used for the cross section.

figure 1:

MAP OF STUDY AREA



LEGEND

A —— A' Traverse for Cross Section

Water Well + number of well

Perimeter of Study Area

SCALE 1:24 000

1 0 1 MI

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

DOTTED LINES REPRESENT 5-FOOT CONTOURS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

mapped, edited and published by Geological Survey

Figure 2

Carolyn Able
1773 King Avenue
Columbus, OH 43212
614-481-7961

April 1, 1997

Dear Landowner/Homeowner:

I am a senior in the Department of Geological Sciences at The Ohio State University. In order to complete my program of study, I am required to prepare a senior thesis in the geological science field. The project that I have chosen requires mapping the cave system that may be present along the Scioto River. My thesis information will then be used by the Ohio Department of Natural Resources in conjunction with a state-wide mapping project.

In order to develop the most comprehensive and accurate map possible, I will be observing the area where you live for indications of sink holes. I would appreciate your permission to conduct a site inspection of your property. This inspection will not include any time or effort on your part. It will not disturb your property in any way. I will be observing your land only and then recording my findings.

If you should have any questions or concerns, please feel free to call me at the above telephone number. My advisor at OSU is Dr. Gary McKenzie (614-292-0655). My project coordinators/advisors with the Ohio Department of Natural Resources are Dr. Michael Hansen (614-265-6580) and Richard Pavey, Geologist (614-265-6599). These individuals will be happy to speak with you also.

Thank you for your cooperation. I look forward to seeing you in the field. If you should have any insight into information concerning your property, I would be very interested in talking with you.

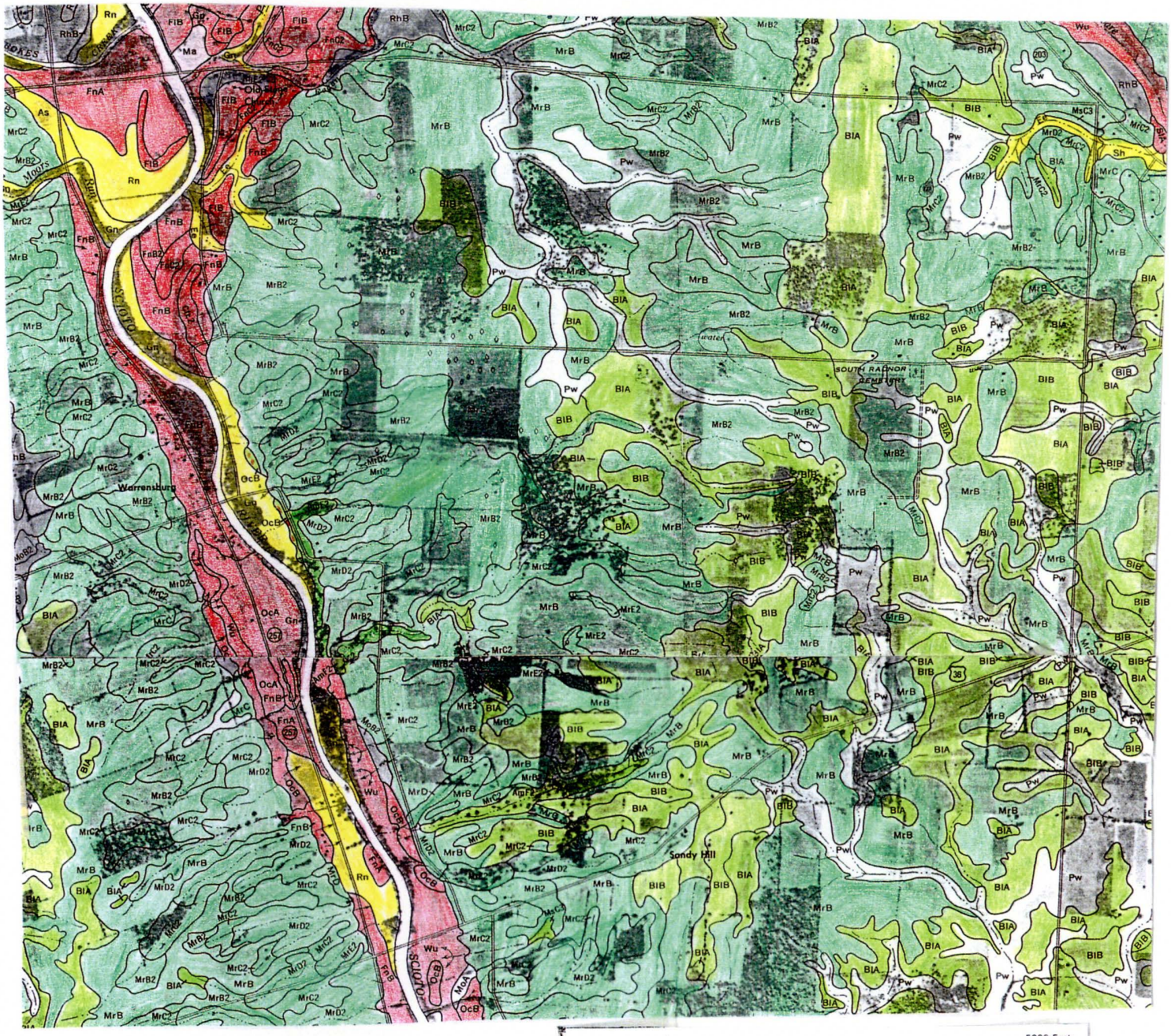
Sincerely,

Carolyn Able

Figure 3

SOIL MAP

N



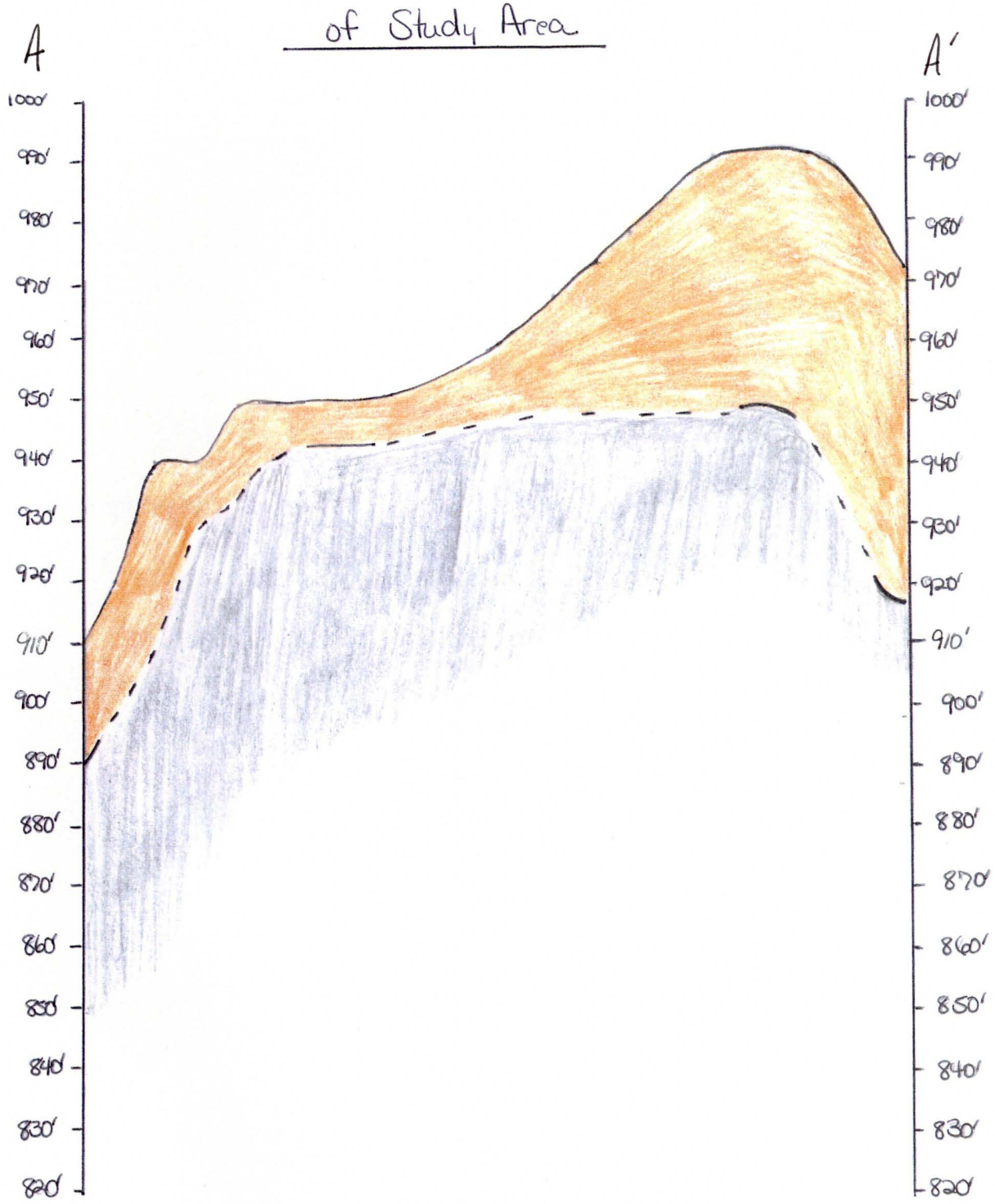
LEGEND

- Morley Silt Loam Soil
- Blount Silt Loam Soil
- Fox ; Ockley ; Westland Silt Loam - Clay Soil
- Ross Silt Loam Soil
- Pewamo Silty Clay Loam

Reproduced from the Soil Survey
Delaware County, Ohio

Figure 4

Cross Section of Study Area



Scales

0 1000' Horizontal ½" = 1000'

0 10' Vertical 1cm = 10'

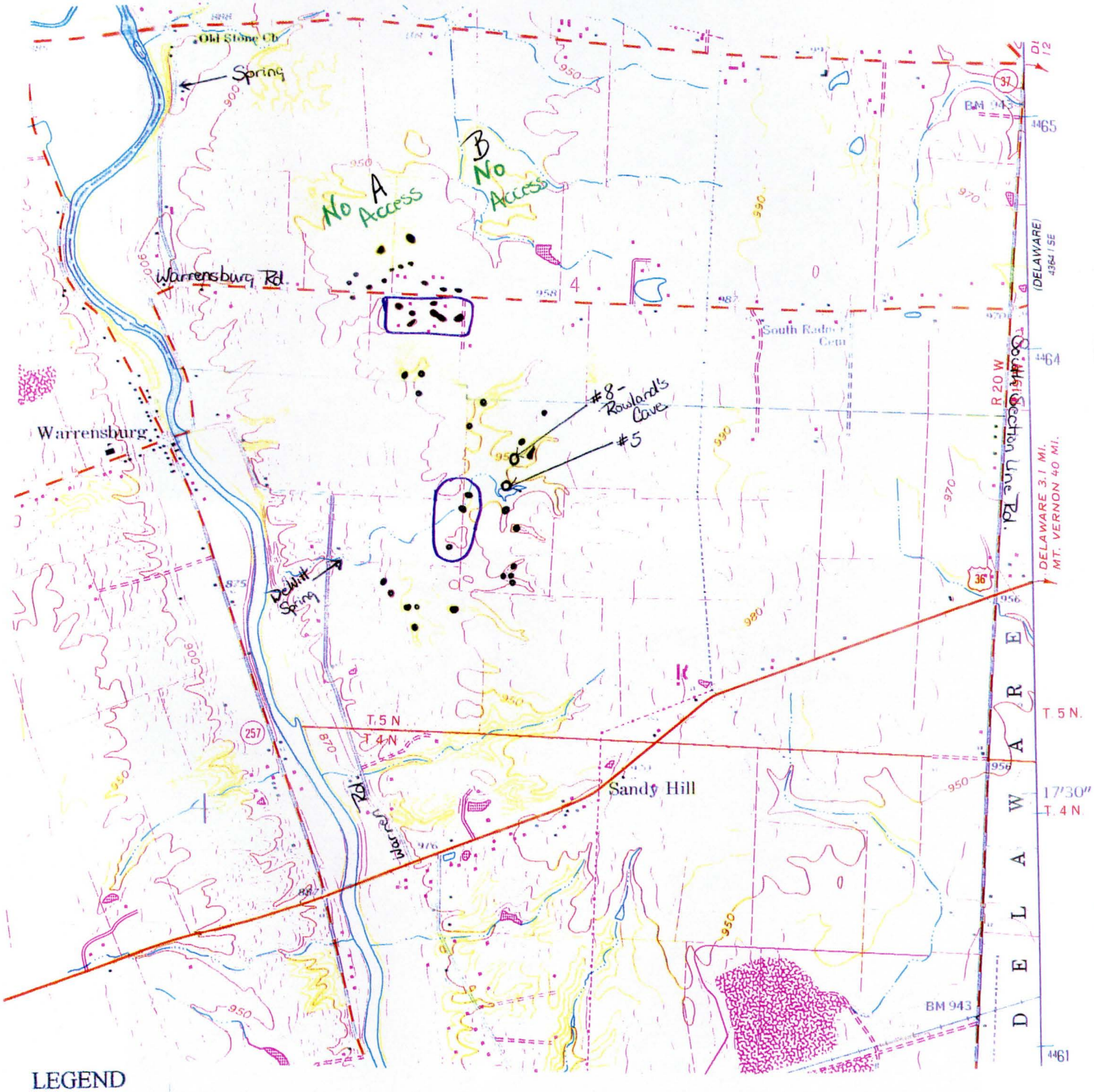
Legend

- Clay / till
- Limestone

Figure 5

CAVE AND SINK HOLE MAP

mapped, edited and published by Geological Survey



LEGEND

- Sinkhole
- Cave
- Indicates that sinkholes can be determined from Aerial photographs

SCALE 1:24 000

1 0 1/2 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure 6

Dye Tracer Testing Pictures

A.

B.

Provided by: Mr. L. DeWitt

Figure 7

Reproduced from: Westgate Source

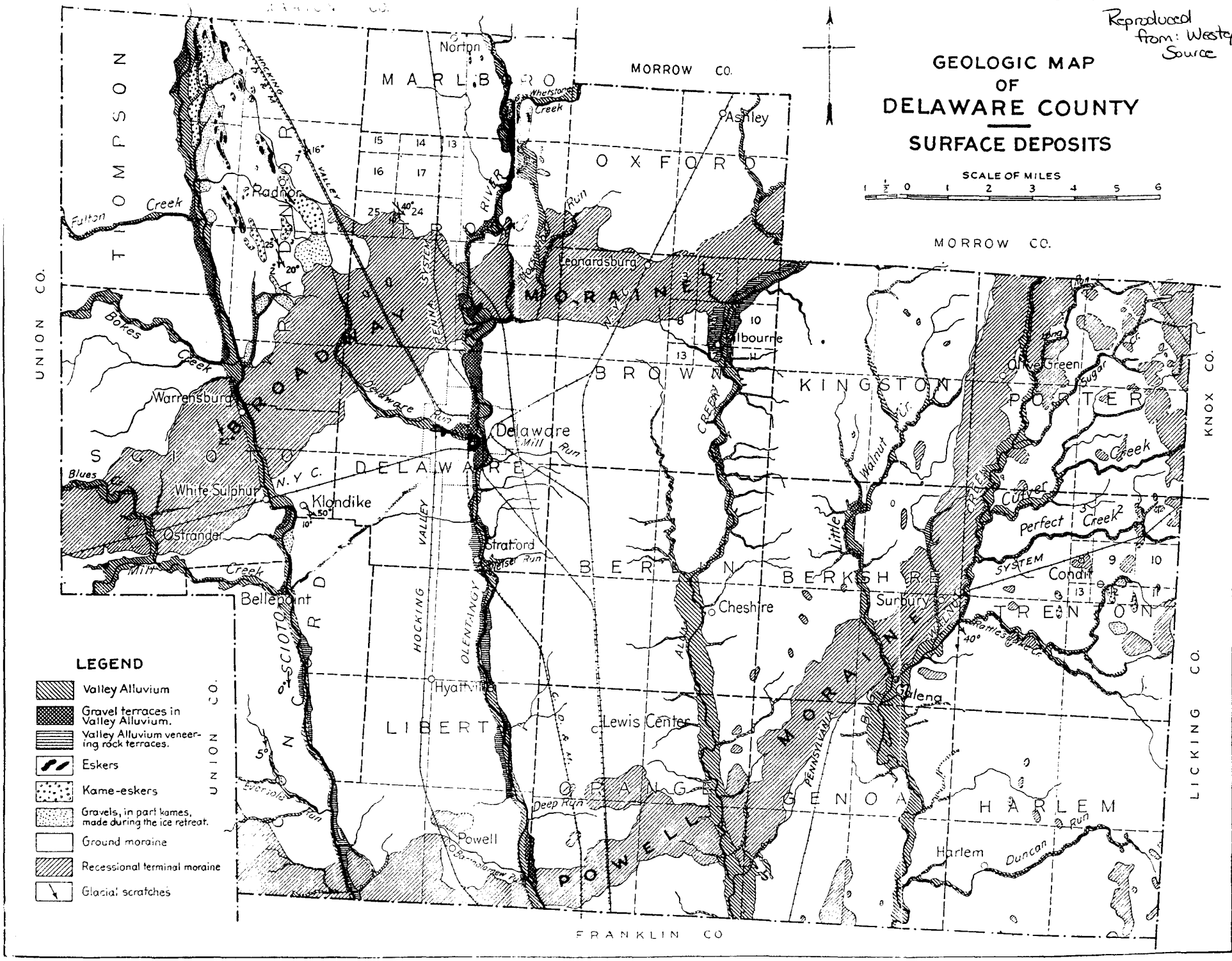


Figure 8

Aerial Photograph

N

example of Sinkhole area

Figure 9

Aerial Photograph

N

Figure 10

WELL LOG AND DRILLING REPORT

ORIGINAL

2-11

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

LOCATED

No. 177777

County DELAWARE Township SCIOTO Section of Township

Owner WM JAY VAN BRIMMER Address OSTRANDER O RD #1

Location of property 1 MI NORTH OF RT 36 ON TWP RD #173 E. SIDE OF RIVER

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 32'
Type of screen Length of screen
Type of pump
Capacity of pump
Depth of pump setting
ate of completion

BAILING OR PUMPING TEST

Pumping rate 20 G.P.M. Duration of test hrs.
Drawdown 2 ft. Date JAN 25-56
Developed capacity
Static level—depth to water 41' ft.
Pump installed by

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From 0 Feet	To Ft.
CLAY	0	18
LIMESTONE - L. BROWN	18	60
" " - BLUE	60	70

910
18
892

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.

N.

W. E.

S.

43

See reverse side for instructions

Drilling Firm LELAND DEWITT Date JAN 25-56

Address DELAWARE O Signed Leland DeWitt

LOCATED

2

FIGURE 11
X= 1,822,500 ±2,000'
Y= 238,900N

LOCATED

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Columbus, Ohio

ORIGINAL

39-54 (1)

No. 86709

County Delaware Township Radnor Section of Township or Lot Number

Owner John Rowlands Address RR#1 Delaware

Location of property 4 mi. West of Intersection 37+203 SR37

CONSTRUCTION DETAILS

Casing diameter 4 Length of casing 55

Type of screen — Length of screen —

Type of pump Deep Well

Capacity of pump 8 G.P.M.

Depth of pump setting 60'

PUMPING TEST

Pumping rate 8 G.P.M. Duration of test 2 hrs

Drawdown 3 ft. Date 4/1/52

Developed capacity 8 G.P.M.

Static level—depth to water 40' ft

Pump installed by Owner

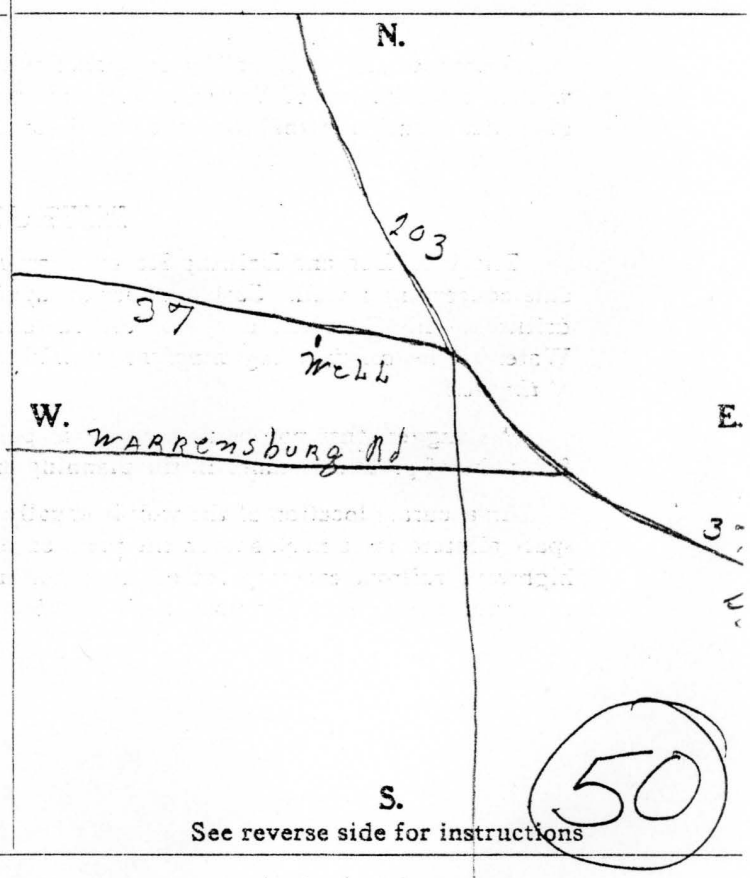
WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	54 Ft.
Limestone	54	65'

955
54
901

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



50

See reverse side for instructions

Drilling Firm [illegible]

Address Millgrove Center O

Date 4/1/52

Signed Edward D. Bowers

LOCATED